RFI Note #003

Design of an 805 MHz BPF Filter for the High Energy Section of the Linac at Fermilab

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Abstract: *Testing the current configuration of the LLRF in the linac at FNAL requires that the Litton 12MW/805MHz klystrons be switched on and off. Frequent power cycling of these klystrons will reduce their filament life significantly. To avoid such an unnecessary wear on the klystrons, an effort is being made to create a simulated klystron/accelerating cavity feedback system.*

I. Introduction

The high-energy section of the LINAC at Fermilab uses Litton 12MW/805MHz klystrons. There are a total of 8 such Litton klystron RF stations, seven of which are for day-to-day operation, and one for testing the spare klystrons as well as the supportive sub-systems. Among the supportive sub-systems, a very important one is the low-level RF system (LLRF). With the standard configuration which we currently have, testing LLRF requires the klystron be turned on. Powering klystrons on and off will reduce their filament life significantly. An effort is being made to create the simulated klystron/accelerating cavity feedback signals to avoid such an unnecessary wear on the klystrons. It is desired to feed the LLRF with the simulated klystron/cavity signals, so that the test of LLRF sub-system can be conducted without having to powering on the klystron. The cavities of the klystrons and the beam accelerating cavities have a center frequency of 805 MHz, and a Q ranging from 10,000 to 20,000. To make the simulated feedback signals looked like they have gone through the cavities and klystron, the 805MHz signals must be filtered with a bandpass filter of same center frequency and with a similar Q. For the given frequency and required Q, it seems that such a filter can only be implemented with either a high-Q cavity, or a crystal filter of much lower frequency with the aid of frequency up/down converters. Comparing the performance , degree of complexity, and the costs of the two approaches, the high-Q cavity

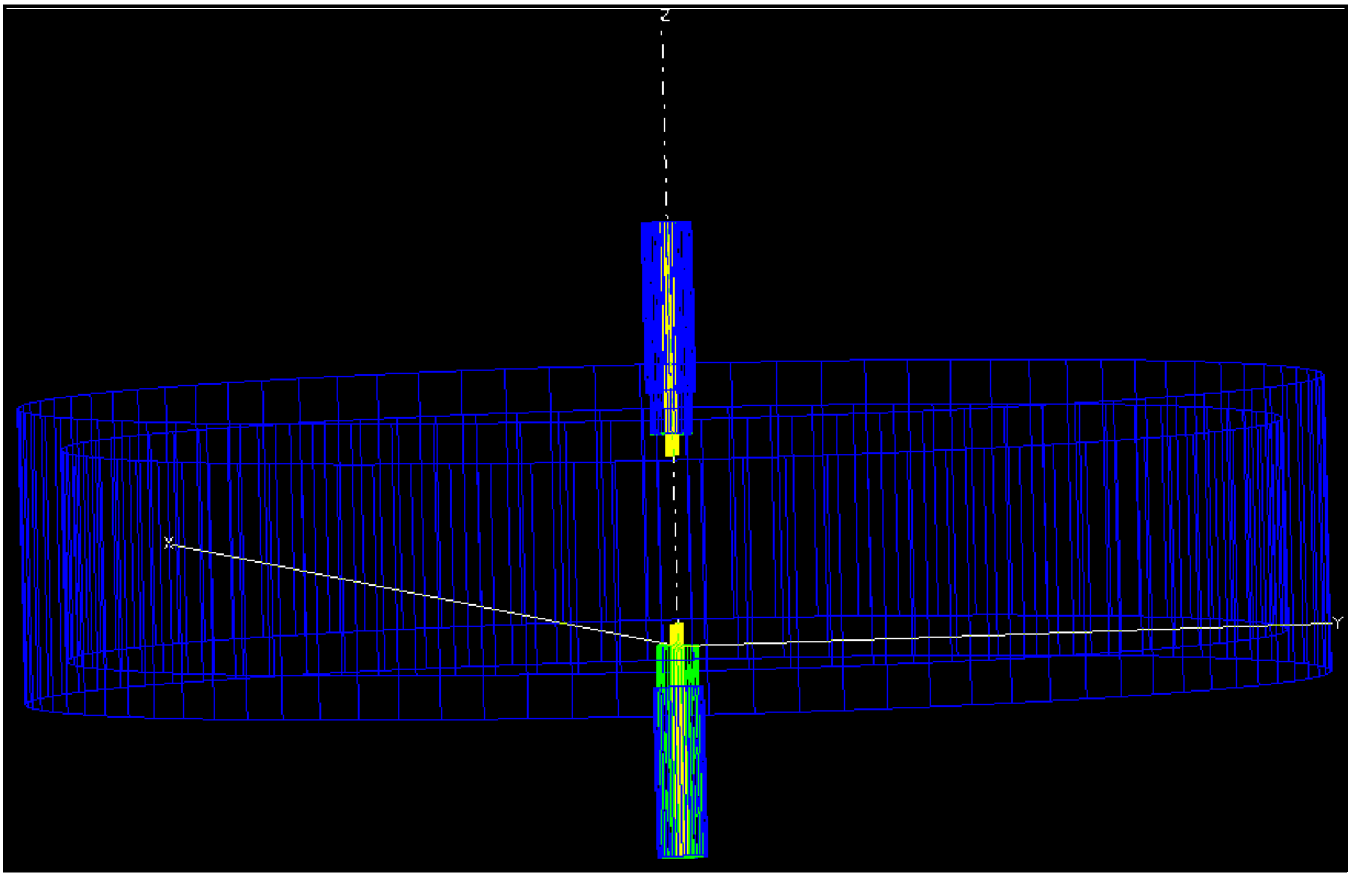

Figure 1. The HFSS plot of the cavity. The center conductor is yellow, and the copper cavity is in blue. The green region is teflon, and both connectors use teflon between its center conductors. The cavity was designed to be cylindrically symmetric, and the coupling antennas are located at the center of the symmetry.

wins. The design procedure will be presented in this paper and the results shown.

II. Design Procedure.

The cavity was designed using HFSS, an electromagnetic code developed by Ansoft Corporation. The picture of the structure simulated for the design is shown in Fig. 1. The main problem with designing this structure was finding the proper Q of the cavity for the mode of filtering. The mode chosen to do the filtering is the TM_{010} mode. This was optimized by fixing the radius of the coupling antennas but demanding that the coupling antennas probe into and out of the cavity. A circular cavity was decided upon for ease of fabrication. The material used in the design was copper and it had a $Q_{external}$ of nearly 14000.

The cavity parameters are:

- Cavity made of Copper
- Cavity radius is 14.2 cm
- Cavity height is 5 cm.
- Cavity antennas must penetrate 5 mm into the cavity.
- The antennas have a radius of 4 mm
- N connectors are used with a 50 Ω transmission line to couple energy from the ports into the cavity.

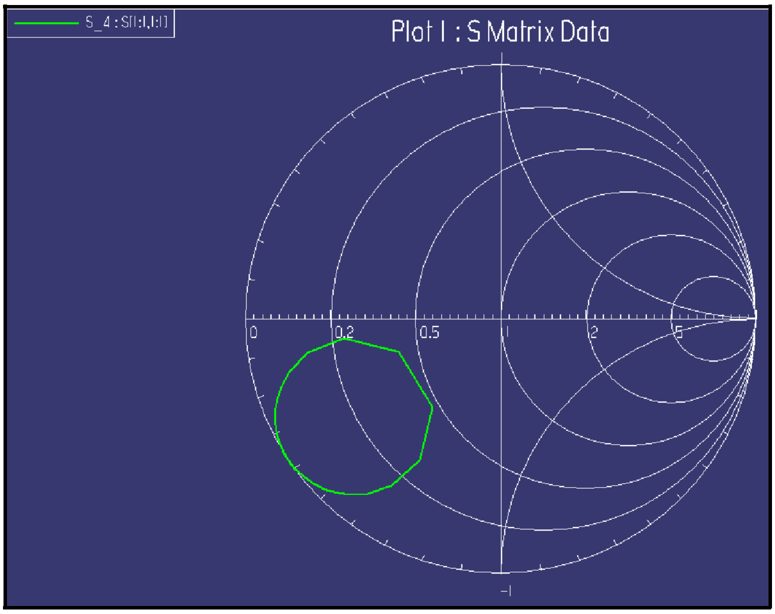

Figure 2. The results of the simulation for the cavity shown in Fig. 1. The coupling can be increased by increasing the antenna penetration into the cavity. The Q of this particular mode is 14,000.

The results of a cavity of this nature is shown in Figs. 2 and 3. The cavity resonance is shown that it is slightly too low and this can be tuned with a set of tuning screws. One of the tuning screws is located at a position on the cavity where it will interrupt primarily electric field. The other tuning screw (along the equator) is located at a position where it will interrupt primarily magnetic field. Two tuning-screw locations are shown in Figs. 4 and 5.

Figure 4 shows how I envision that the cavity should be

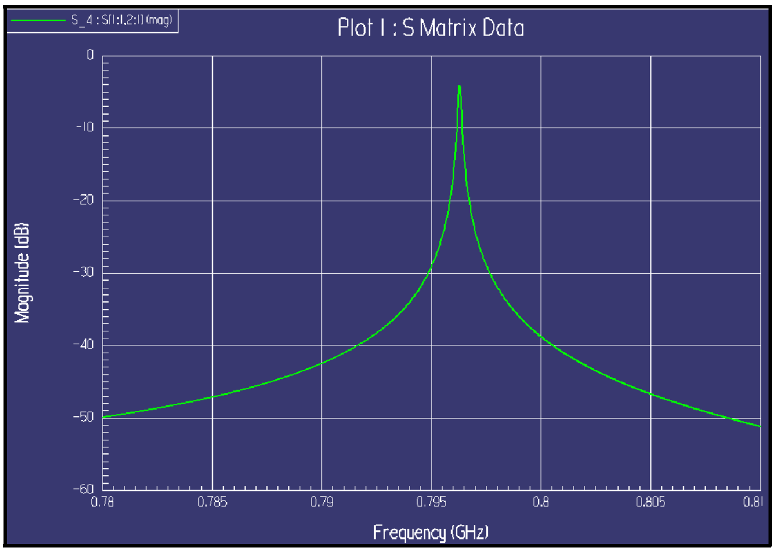

Figure 3. The transmission from port to port for the cavity in Fig. 1.

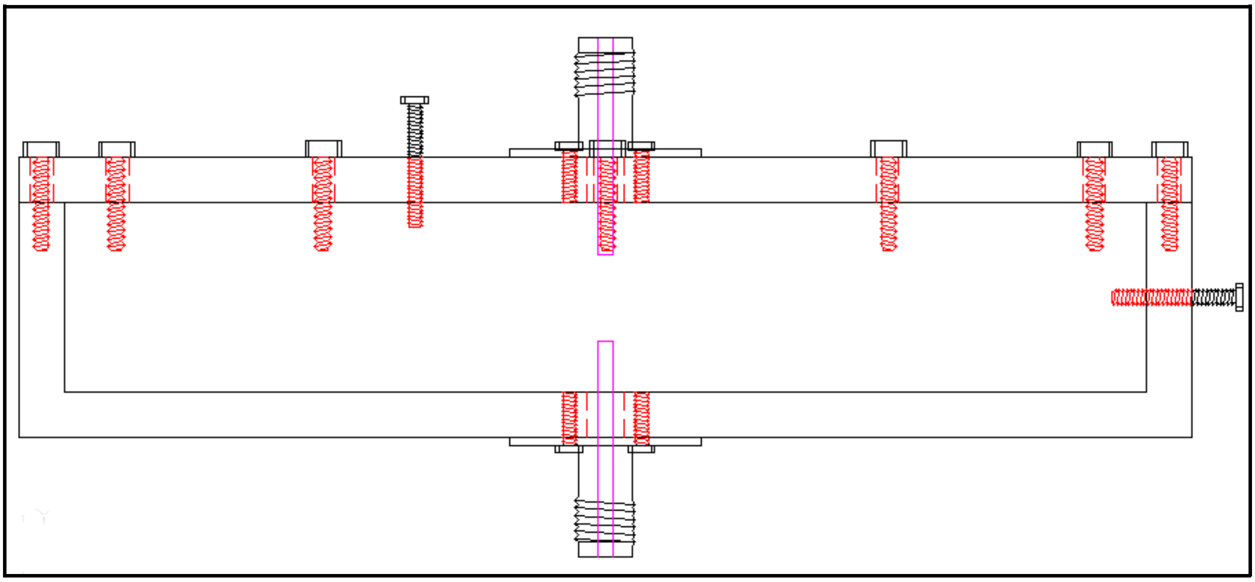

Figure 4. A schematic of the cavity of Fig. 1. The cavity walls are assumed to be 1.2 cm thick. The two tuning screws are shown. One screw disrupts electric field, the second disrupts magnetic field. The top plate is envisioned to screw tightly to the cavity body.

manufactured. Screws will hold the lid of the cavity onto its body. N-connectors were chosen for their ruggedness and their availability. The antenna is manufactured on a lathe and the center of the antenna should slip over the N-connector center conductor, and held in

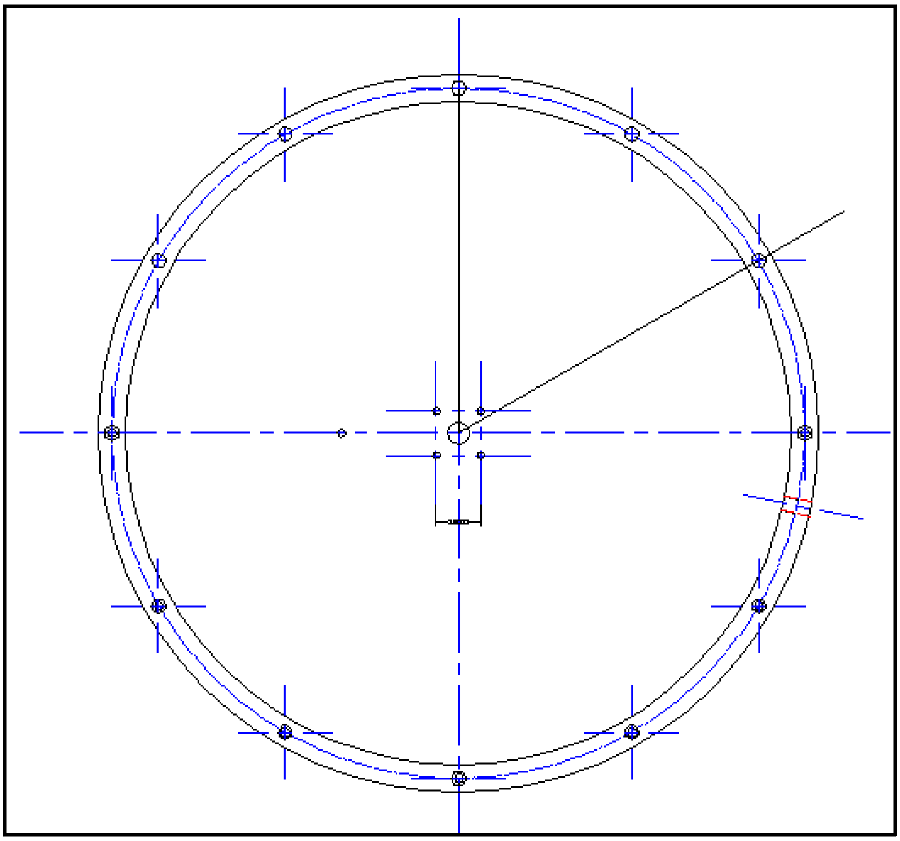

Figure 5. Schematic drawing of the cavity. The tuning hole locations are shown as well as the location of the holes for the N-connector and the screws to hold the lid onto the cavity.

place with some solder.

Since the cavity is only envisioned to be used for short term (on the order of several hours), it is not necessary for it to be temperature controlled. A blanket could be placed over the outside of the cavity to inhibit small temperature variations due to air drafts. Additionally, for system stability, it may be required for the end user to place some 5 dB attenuators on each port of the cavity.

III. Conclusion

The high-energy section of the LINAC at Fermilab uses Litton 12MW/805MHz klystrons. The cavities of the klystrons and the beam accelerating cavities have a center frequency of 805 MHz, and a Q ranging from 10,000 to 20,000. These cavities can be simulated for testing the LLRF of the linac with the cavity designed in this paper.

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